

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



# Optics of Eye

Lecture 2

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# Learning Outcomes

- Describe Reduced Eye.
- Explain Accommodation of eye.
- Describe the Autonomic innervation of eye.
- Describe the control of pupillary aperture and Pupillary Light Reflex.
- Describe Horner's Syndrome.
- Describe Argyll Robertson's Pupil.
- Explain the pathophysiology of Cataract.
- Describe Visual Acuity.

# Eye As A Camera

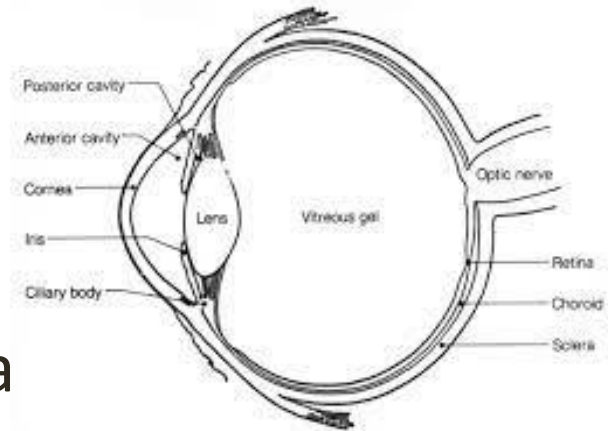
Eye has a

- Lens system
- A variable aperture (pupil)
- A photographic film (retina)

# Lens System Of The Eye

## Four interfaces

- Air and anterior surface of cornea
- Posterior surface of cornea and aqueous humor
- Aqueous humor and anterior surface of the lens
- Posterior surface of lens and vitreous humor



# Refractive Index

RI= Velocity of light in air/velocity of light in that medium

Velocity of light in air is 300,000 km/s

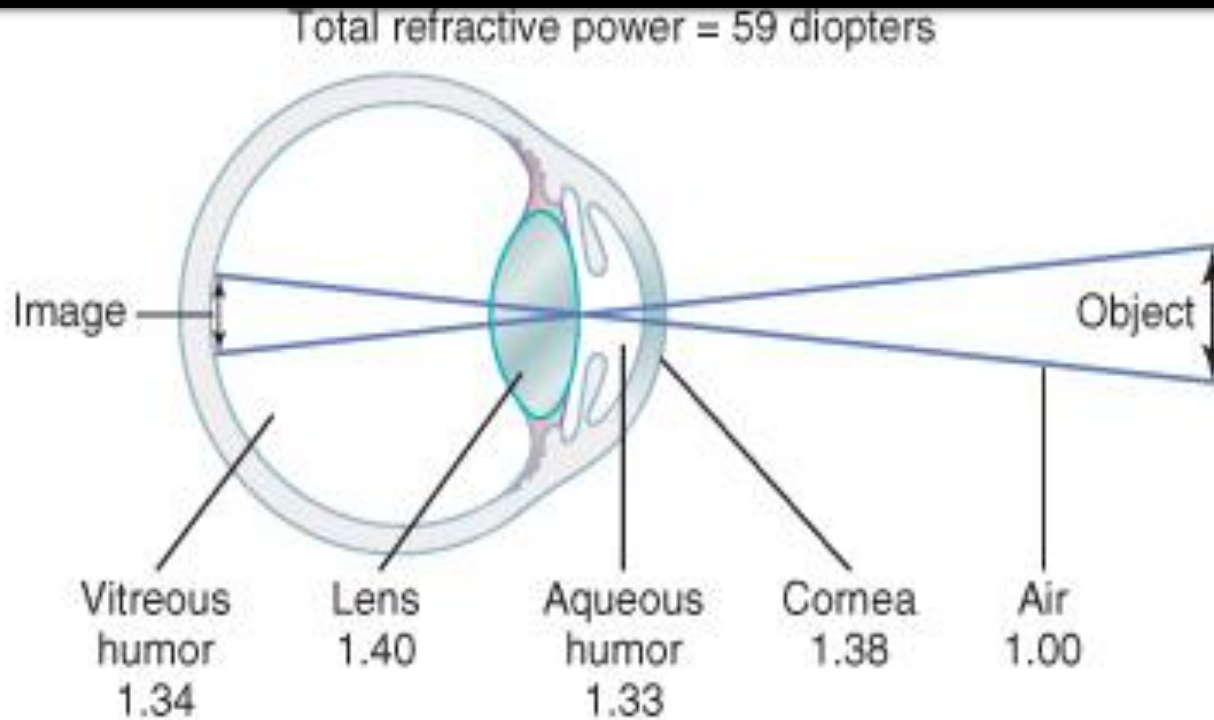
So, RI of air =  $300,000/300,000=1$

Refractive indices of other transparent media are greater than 1

# What Is Reduced Eye?



# Reduced eye



The numbers are the refractive indices.

# Refractive Indices

- Air  $\rightarrow$  1
- Cornea  $\rightarrow$  1.38
- Lens  $\rightarrow$  1.40
- Aqueous Humor  $\rightarrow$  1.33
- Vitreous Humor  $\rightarrow$  1.34

# Lens System of the Eye

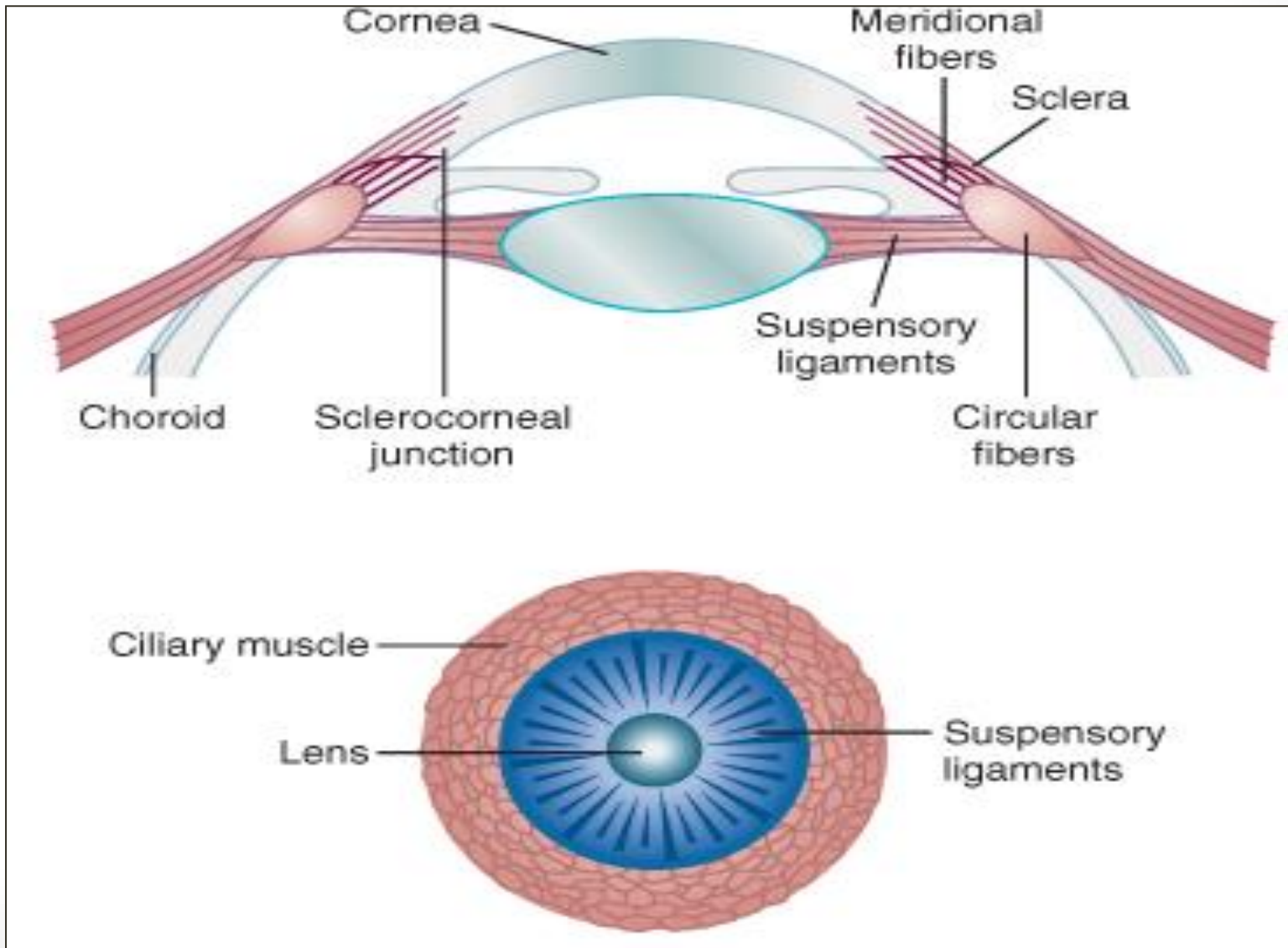
- Total Refractive power is **59 diopters**
- **Maximum Refraction – CORNEA; 40 diopters**
  - Refractive indices difference of air and cornea  
0.38 (1.38 – 1.00)
- Refractive power of **LENS** is **20 diopters** only
- Lens - provides **accommodation** for different distances of the object from the eyes

# Accommodation

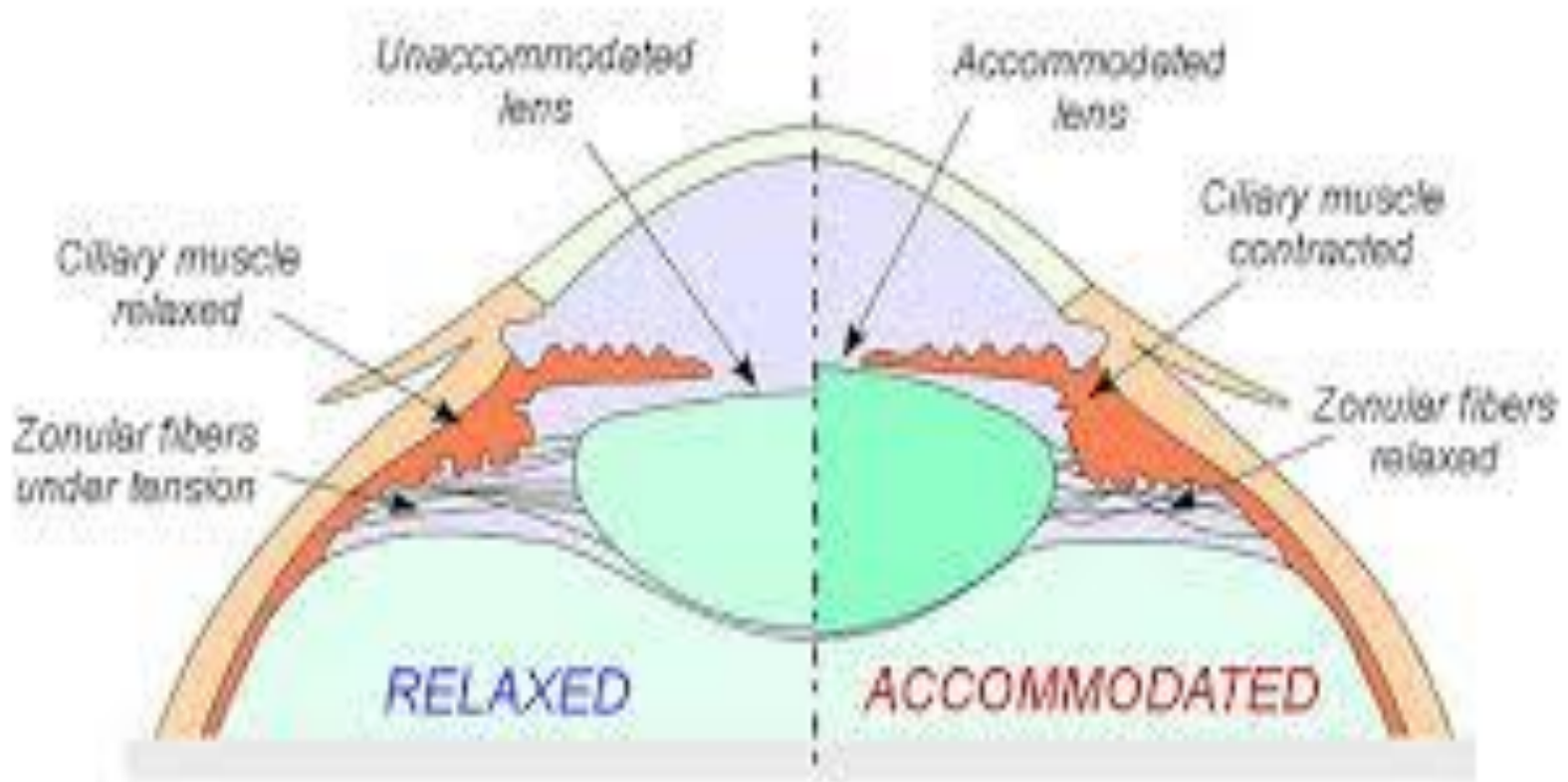
# Accommodation Power

- Parallel light rays are focused on retina by **59 diopters** power of the lens system
- Light rays from near objects are diverging
- More powerful lens required to focus the near objects
- Refractive power of the crystalline lens can be increased from **20 diopters to 34 diopters**
- This **14 diopters** increase is accommodation power

# Mechanism of Accommodation

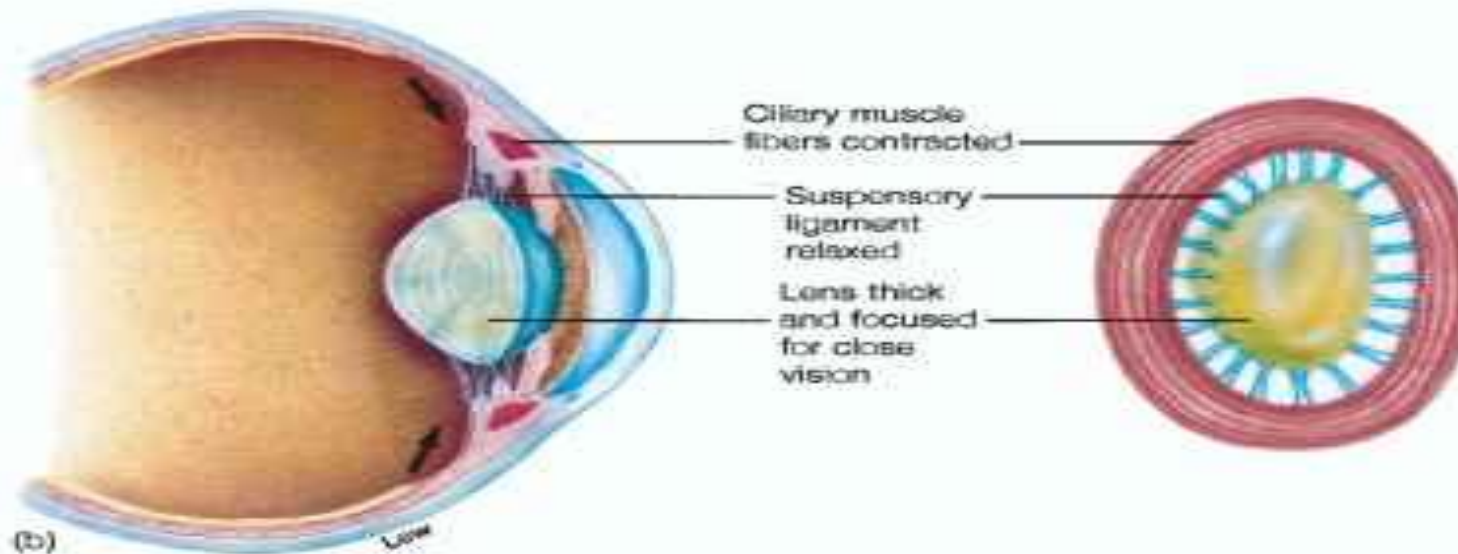
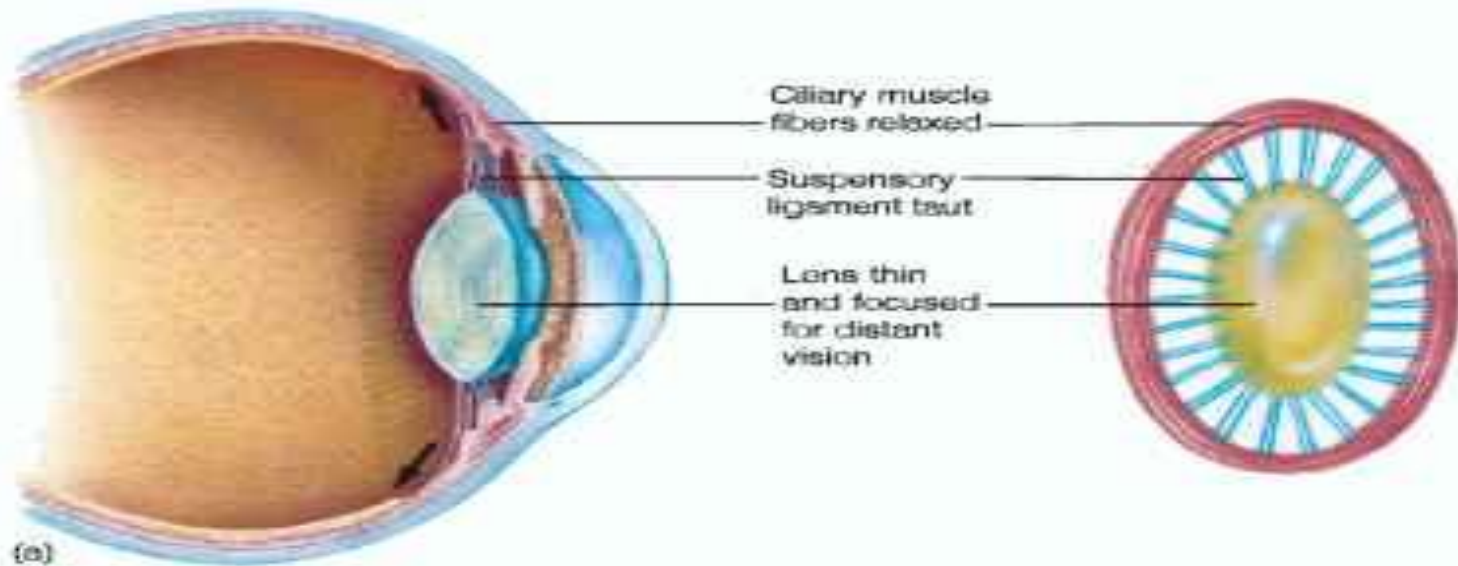


# Accommodated & Unaccommodated Lens



ACCOMMODATION IN THE NORMAL EYE

# Accommodation





# Mechanism of Accommodation

- Lens capsule is strong transparent elastic filled with **transparent proteinaceous fluid**
- About **70 suspensory ligaments** attached at periphery, connecting the lens to ciliary muscles
- These ligaments are radially arranged and collectively called '**zonule**'
- In relaxed state lens becomes almost spherical, a transparent ball

# Ciliary Muscles

2 sets of muscle fiber

- **Meridional fiber** –

Contraction pulls the attachment site anteriorly and releases some of the tension of ligaments

- **Circular muscle fibers**- contraction reduces the total diameter of attachment site and greatly reduces the tension on the ligament

- Both contract by the action of **parasympathetic fibers** in the oculomotor nerve, 3<sup>rd</sup> cranial nerve

# Positive Accommodation

Contraction of ciliary muscles →

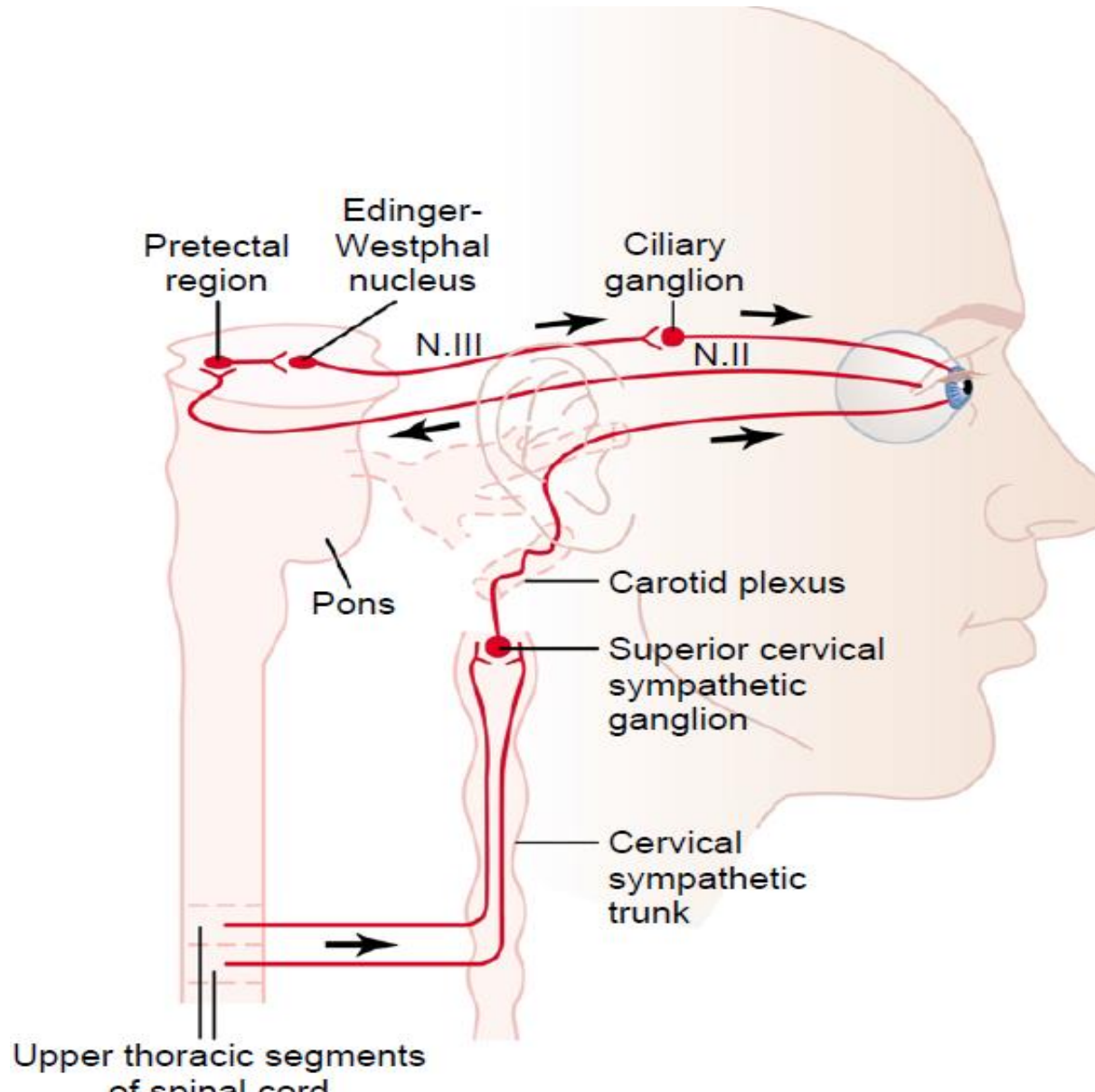
- Reduced tension on zonular ligaments
- More spherical shape of the lens
- ↑ refractive power
- **Positive accommodation**
- Accommodation for **near vision**
- **Pupil constricts** in positive accommodation
- **Convergence of eyes** as well

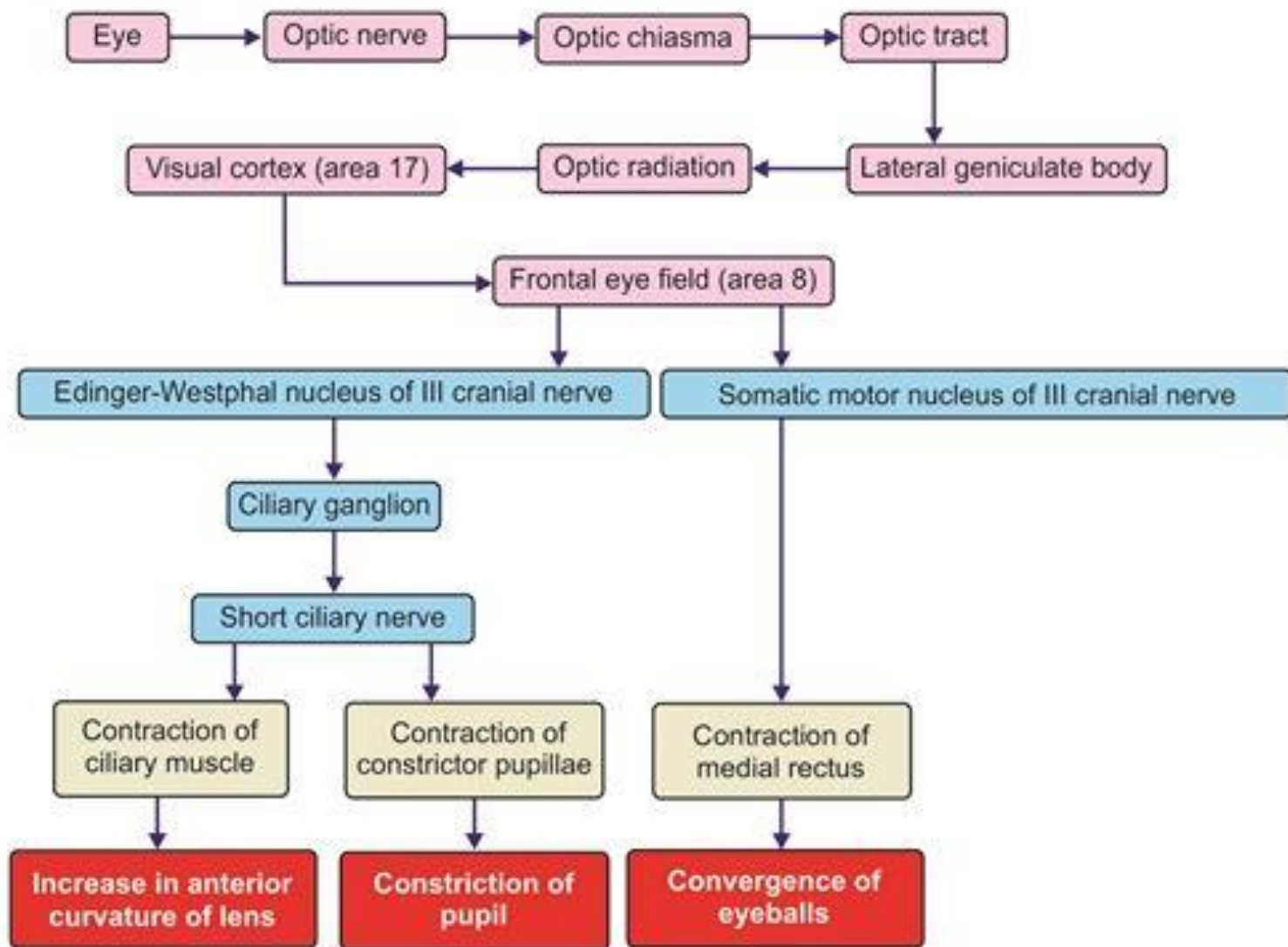
# Negative Accommodation

- Relaxation of the ciliary muscles →
  - ↑ tension on zonular ligaments
  - Less spherical shape of the lens
  - ↓ refractive power
  - **Negative accommodation**
  - Accommodation for **far vision**

# Autonomic Innervation of Eye

# Autonomic Innervation of Eye





# Control Of Pupillary Diameter

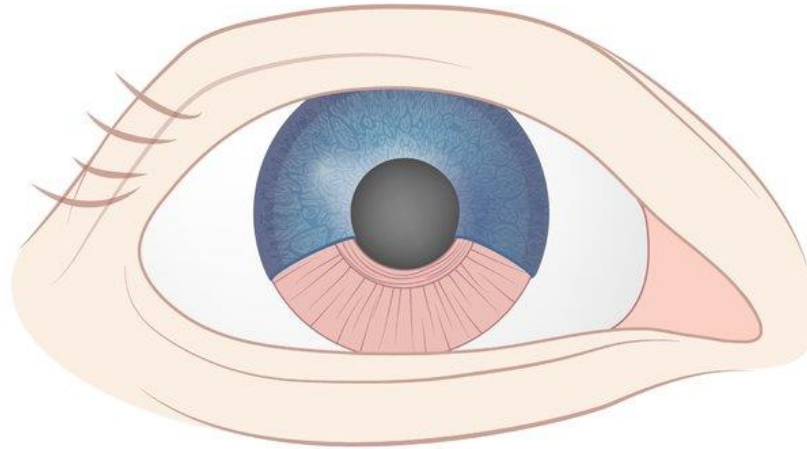
Normal Pupillary size → 4-6 mm

Parasympathetic stimulation excites constrictor pupillae muscle decreasing the pupillary aperture - **MIOSIS**

Sympathetic stimulation excites dilator pupillae of iris (radial muscle fibers)- pupillary dilation called **MYDRIASIS**

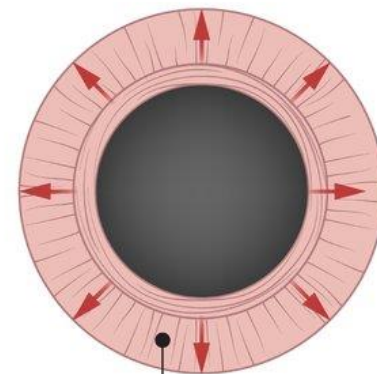
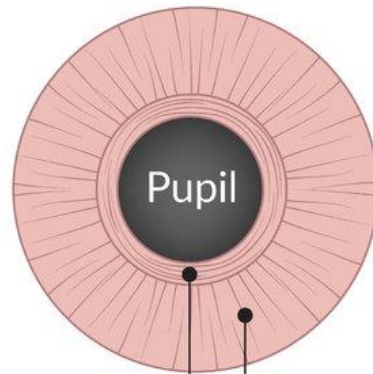
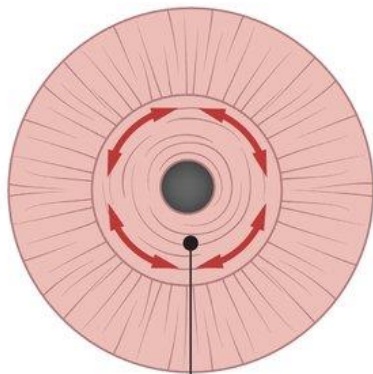


# PUPILLARY DILATION & CONSTRICTION



Parasympathetic stimulation

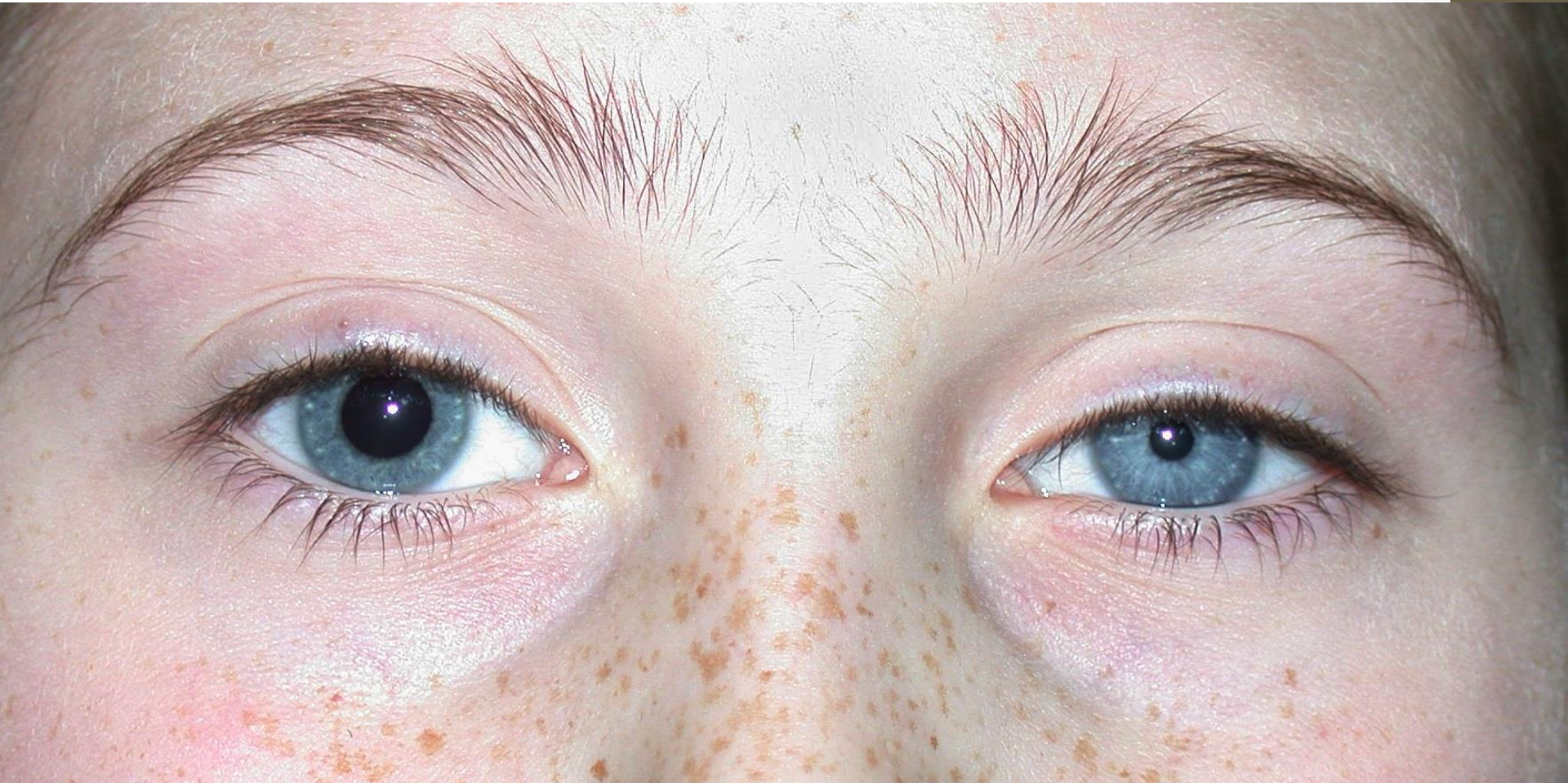
Sympathetic stimulation



Iris sphincter muscle

Iris dilator muscle

# Dilated & Constricted Pupil



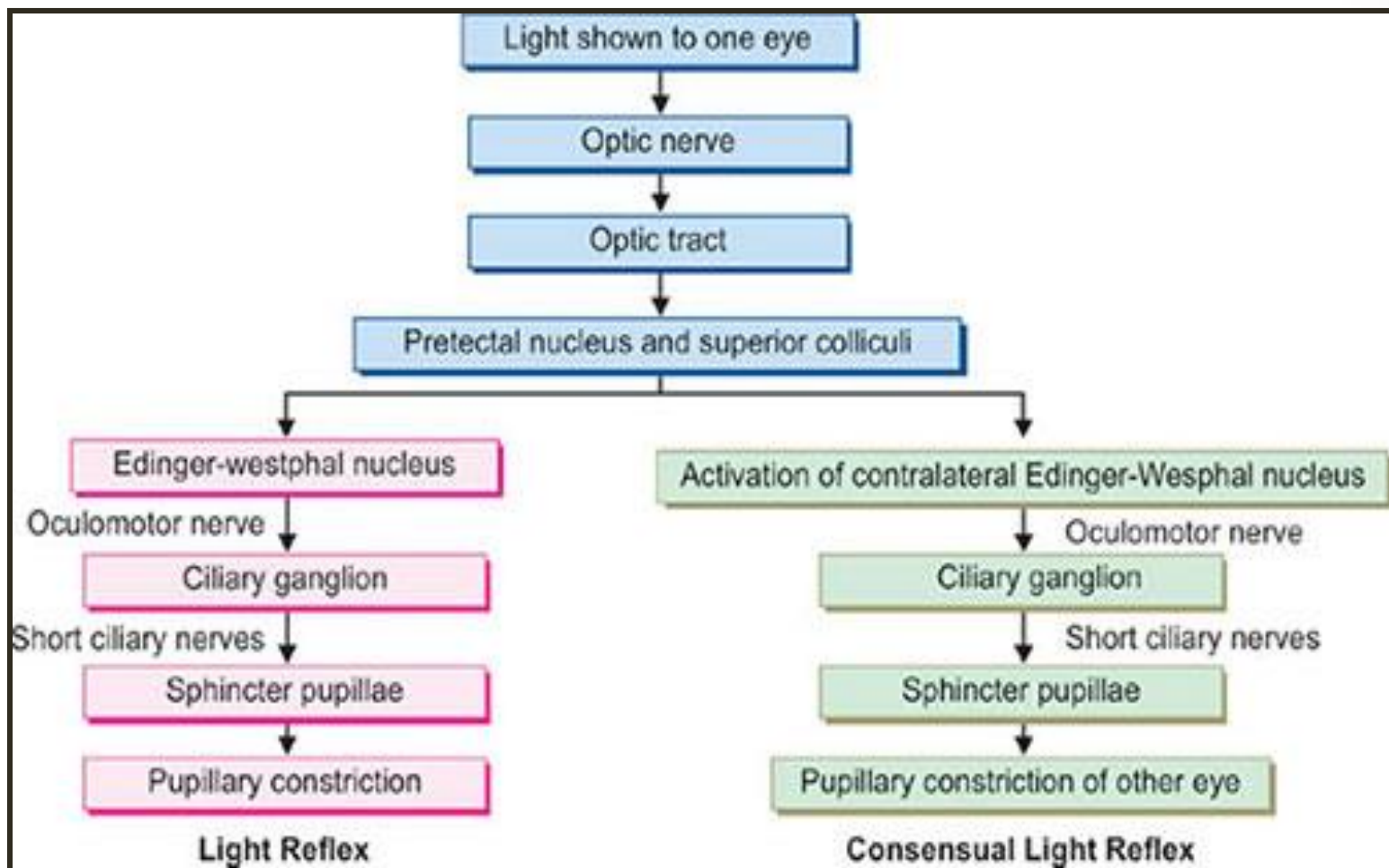
Normal pupils



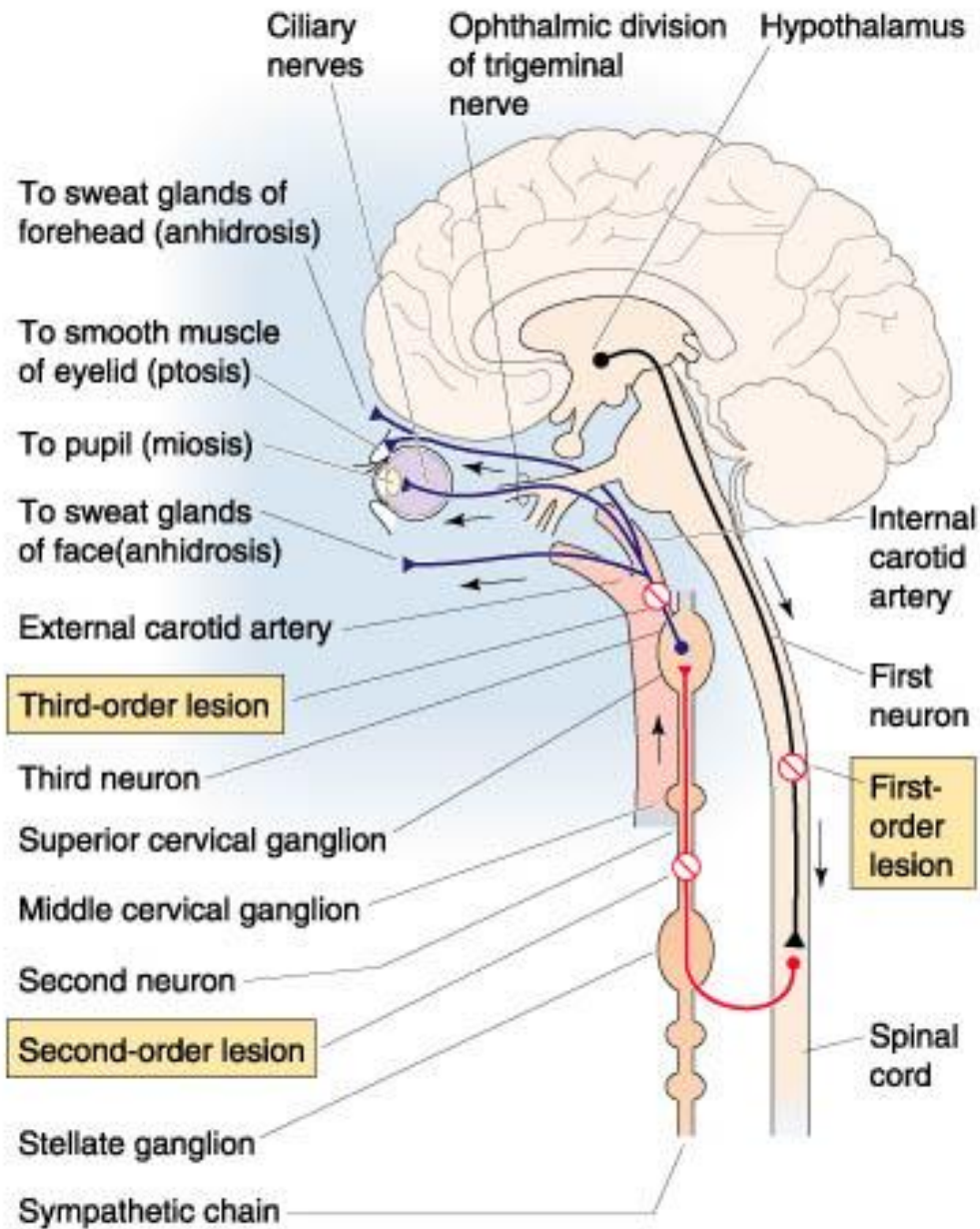
Dilated pupils



# Pathway For Light Reflex



# HORNER'S SYNDROME



# Horner's Syndrome



**Figure 1:** Left pupillary miosis, marked hypochromia of the left iris, ipsilateral mild ptosis and left hemifacial anhidrosis



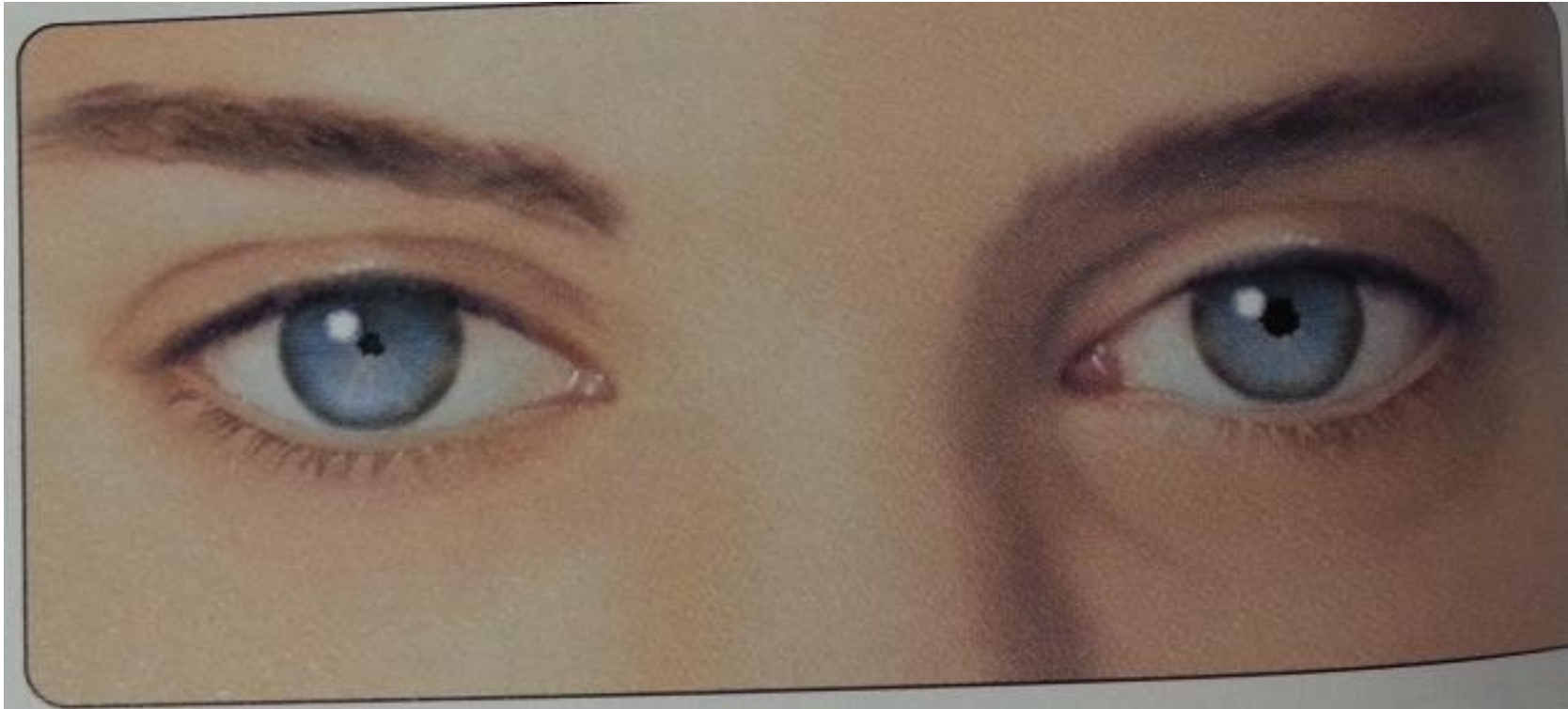
# Horner's Syndrome

Interruption of Sympathetic nerves to the eye  
in cervical sympathetic chain → **Horner's syndrome**  
characterized by

1. unilateral ptosis
2. miosis
3. blood vessels are persistently dilated on the affected side
4. hemifacial anhidrosis (no sweating)
5. hypopigmentation of the iris on the affected side and
6. enophthalmus

HHUMBLE

# Argyll Robertson Pupil



# Argyll Robertson Pupil

## **ABSENCE OF LIGHT REFLEX**

- pupillary constriction to accommodation and convergence reflex is maintained
- Size of pupil is **less than 3 mm**
- **Sign of neurosyphilis**
- also seen in neoplasms around aqueduct, polioencephalitis, trauma, diabetic neuropathy etc

**Typical ARP** is always

**bilateral,**

**miotic**

**having irregular margins**

# Pupillary Aperture

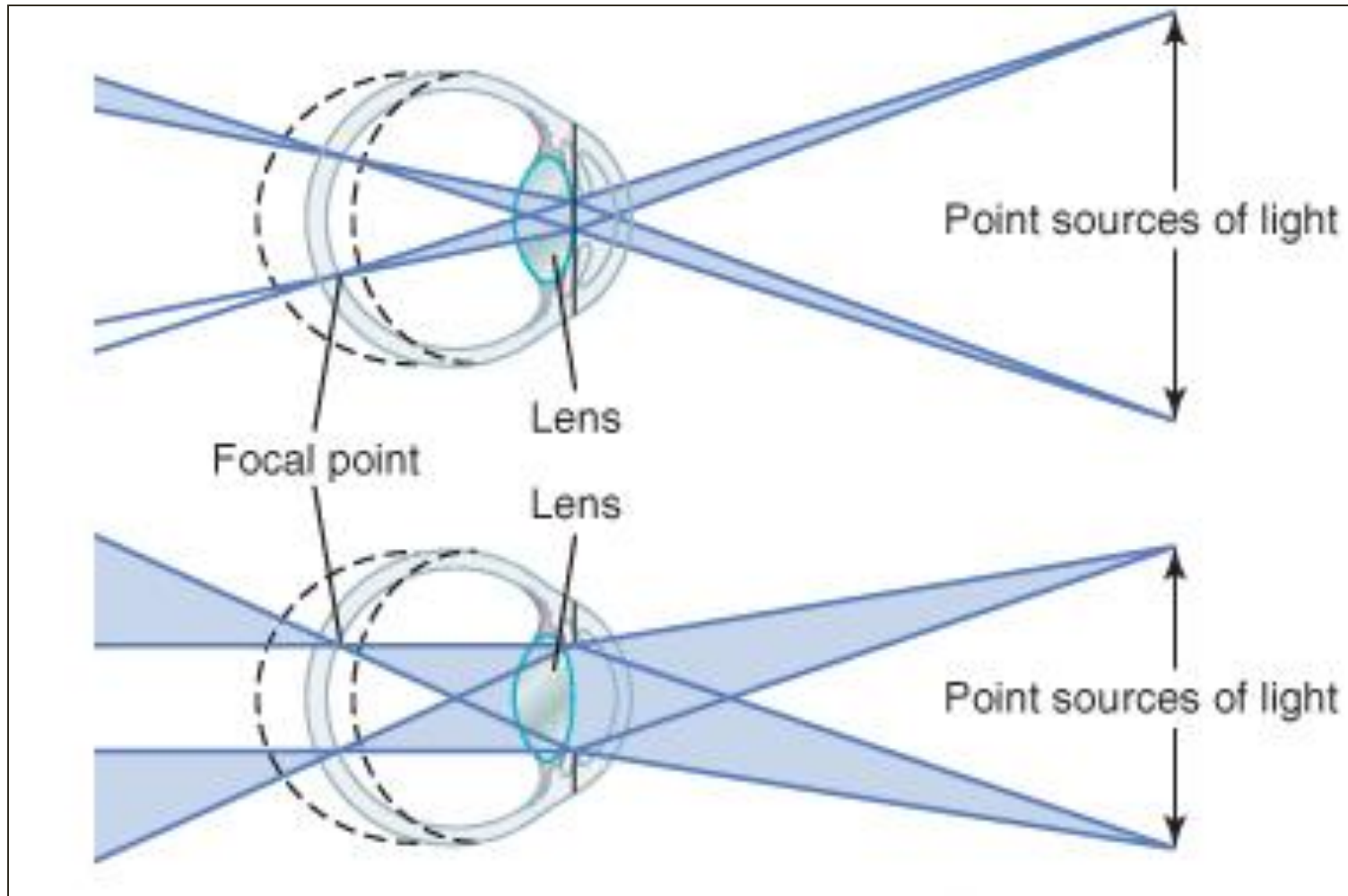
## **Control of amount of light**

- Diameter of pupil 1.5 to 8 mm
- Amount of light is proportional to Diameter<sup>2</sup>
- Amount of light can vary up to 30 times

## **Effect on depth of focus**

- Constricted pupil increases the depth of focus
- All the light rays pass almost the center of lens
- Central light rays are always better focused
- Principle of pin hole camera

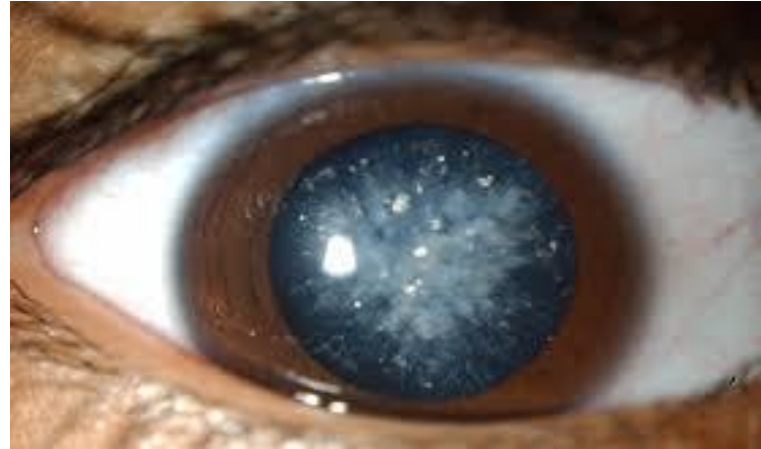
# Pupillary Aperture And Depth Of Focus



Effect of small (top) and large (bottom) pupillary apertures on "depth of focus."

# What is Cataract?

# Cataract



# Cataract

- Common in **older** people
- **Cloudy or opaque** area/areas in lens
- **Mechanism**
  - Proteins in lens become **denatured**
  - and form a **coagulum** in place of normal transparent protein fibres
- Impairs light transmission and impairs vision
- **Replacement** by an artificial plastic lens



# VISUAL ACUITY

# Visual Acuity

**Sharpness of vision**

**Two points discrimination**

- 2-point sources of light will be discriminated if their focal points at the central retina are at least **2  $\mu\text{m}$**  away

# Visual Acuity

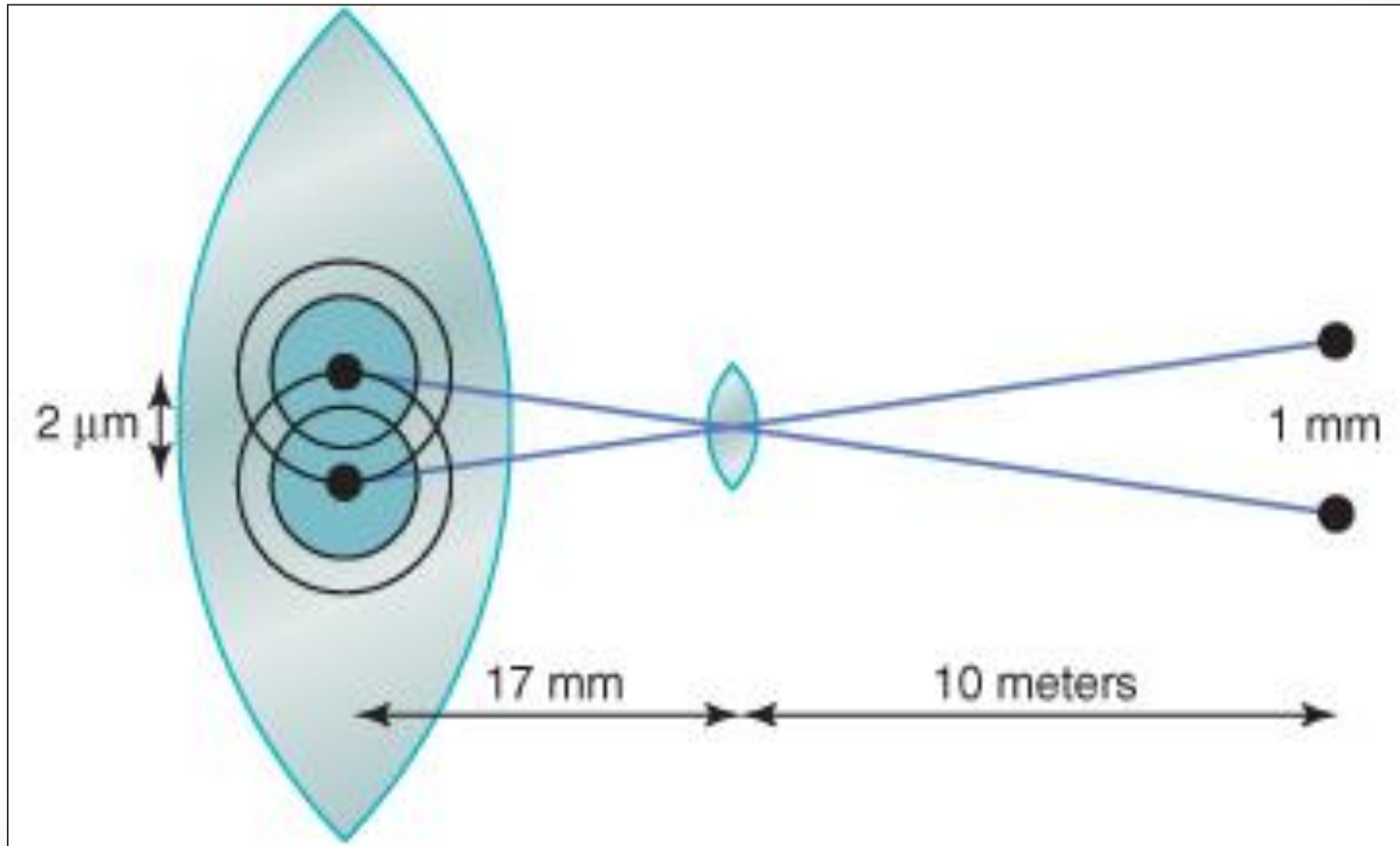
## Central Retina

- Maximum visual acuity
- Each cone is connected to separate optic nerve fiber
- Cone diameter is only **1.5  $\mu\text{m}$**

## Peripheral Retina

- Visual acuity is reduced
- Several rods and cones converge on a single optic nerve fiber
- Cones are much thicker 5-8  $\mu\text{m}$

# Maximum Visual Acuity



Far Vision

Snellen's Chart

E

1 20/200

F P

2 20/100

T O Z

3 20/70

L P E D

4 20/50

P E C F D

5 20/40

E D F C Z P

6 20/30

F E L O P Z D

7 20/25

D E F P O T E C

8 20/20

L E F O D P C T

9

F D P L T C E O

10

P E Z O L C F T D

11

# Clinical Method to Test Visual Acuity

- Snellen's chart
- Letters of different sizes
- Every letter or letters line marked for the distance a normal person can read
- The subject must read the chart from a distance of **20 feet or 6 meters**
- If can read letters marked 20 is 20/20 or 6/6 i.e. → normal
- If can read letter at 200 then **VA 20/200 or 6/60** → can read at 20 feet (6 m) distance the letters he should be able to read from 200 feet (60 m)
- VA = ratio of one's VA to VA of a normal person

Near Vision  
JAEGERS'S CHART



No. 1.  
.37M

In the second century of the Christian era, the empire of Roman comprehended the fairest part of the earth, and the most civilized portion of mankind. The frontiers of that extensive monarchy were guarded by ancient renown and disciplined valor. The gentle but powerful influence of laws and manners had gradually cemented the union of the provinces. Their peaceful inhabitants enjoyed and abused the advantages of wealth.

No. 2.  
.50M

four score years, the public administration was conducted by the virtue and abilities of Nerva, Trajan, Hadrian, and the two Antonines. It is the design of this and of the two succeeding chapters, to describe the prosperous condition of their empire; and afterwards, from the death of Marcus Antoninus, to deduce the most important circumstances of its decline and fall; a revolution which will ever be remembered, and is still felt by

No. 3.  
.62M

the nations of the earth. The principal conquests of the Romans were achieved under the republic; and the emperors, for the most part, were satisfied with preserving those dominions which had been acquired by the policy of the senate, the active emulations of the consuls, and the martial enthusiasm of the people. The seven first centuries were filled with a rapid succession of triumphs; but it was

No. 4.  
.75M

reserved for Augustus to relinquish the ambitious design of subducing the whole earth, and to introduce a spirit of moderation into the public councils. Inclined to peace by his temper and situation, it was very easy for him to discover that Rome, in her present exalted situation, had much less to hope than to fear from the chance of arms; and that, in the prosecution of

No. 5.  
.75M

the undertaking became every day more difficult, the event more doubtful, and the possession more precarious, and less beneficial. The experience of Augustus added weight to these salutary reflections, and effectually convinced him that, by the prudent vigor of

No. 4.  
1.25M

his counsels, it would be easy to secure every concession on which the safety or the dignity of Rome might require from the most formidable barbarians. Instead of exposing his person or his legions to the arrows of the Parthians, he obtained, by and honor-

No. 7.  
1.50M

able treaty, the restitution of the standards and prisoners which had been taken in the defeat of Crassus. His generals, in the early part of his reign, attempted the reduction of Ethiopia and Arabia Felix. They marched near a thou-

No. 8.  
1.75M

sand miles to the south of the tropic; but the heat of the climate soon repelled the invaders, and protected the unwarlike natives of those sequestered regions

No. 9.  
2.00M

The northern countries of Europe scarcely deserved the expense and labor of conquest. The forests and morasses of Germany were

No. 10.  
2.25M

filled with a hardy race of barbarians who despised life when it was separated from freedom; and though, on the first

No. 11.  
2.50M

attack, they seemed to yield to the weight of the Roman power, they soon, by a signal

# Determination of distance (Depth Perception)

3 methods for the determination of the distance of the objects from the eyes

1. Size of image of known objects
2. Phenomenon of moving parallax
3. Phenomenon of stereopsis

# Size of image of known objects

- Image of the far objects is smaller than the nearer objects
- Brain knows the size of the image of known object when they are near and change in size when the same objects is far away
- Brain automatically calculates the distance from this

# Phenomenon of moving Parallax



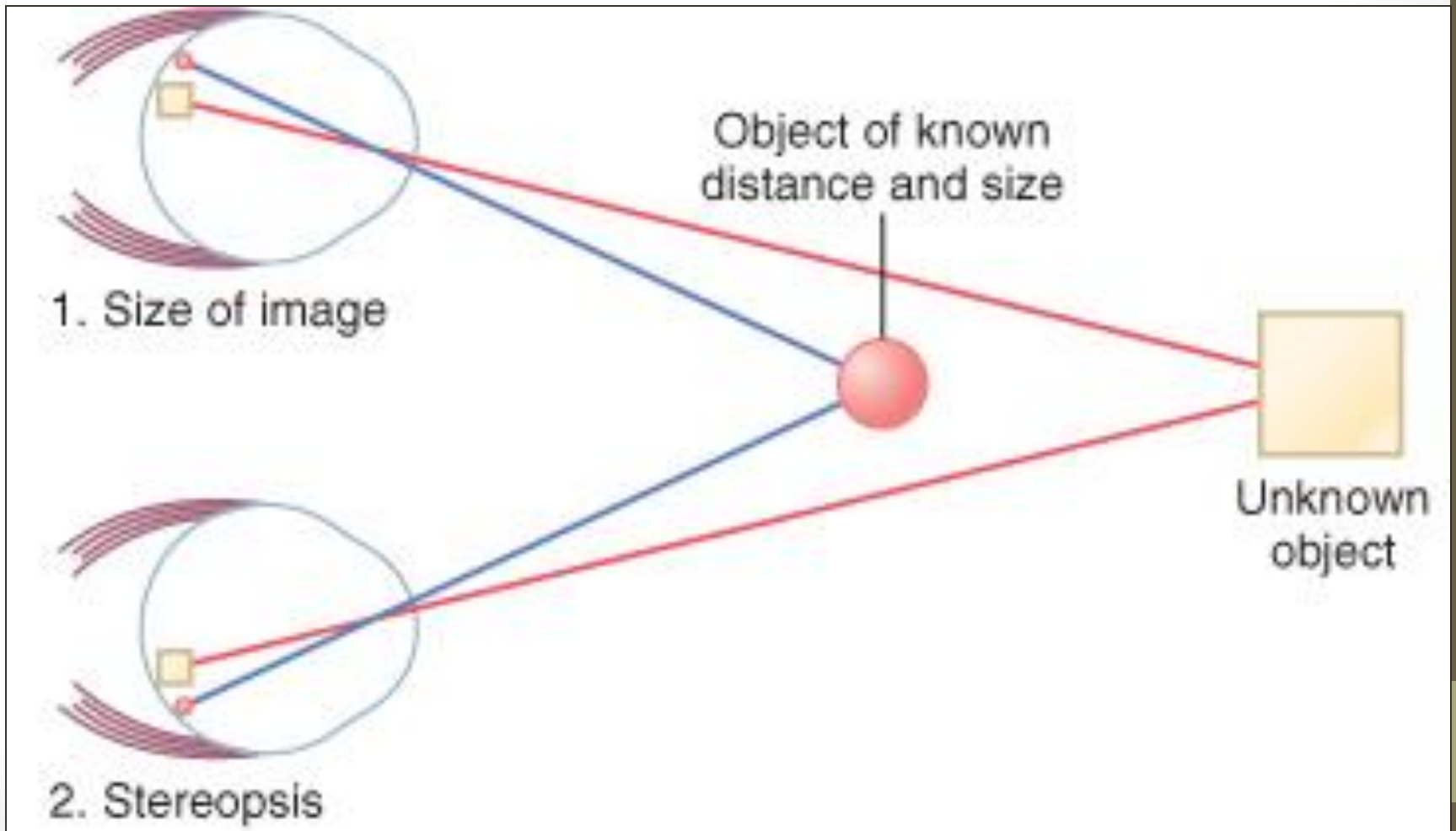
# Phenomenon of Moving Parallax

- Image of the nearer objects moves more across the retina with the movement of the eye
- Very near objects are out of field of vision with small movement of eyes or head
- Far objects image remains on the retina even with tremendous movement of the eye of head
- From this phenomenon brain estimates the distance of objects

# Phenomenon of Stereopsis

- **Binocular vision**
- Object **near to the eyes** forms images on **the temporal side** of the retinae
- As it moves away from the eyes, the images in the two eyes come more towards the nasal sides of the retinae
- Nearer objects have more un-fused points of the two images than the far objects
- From these two phenomenon of binocular vision brain can estimate the distance of the objects

# Distance perception by size and stereopsis



# References

- Guyton and hall Physiology
  - Ganong's Physiology
  - Sherwood Physiology





# Lesson Plan For Next Class

- Visual Pathways
- Visual Field Defects



*Thank You*